

COMPOSITION OF THE LUNAR CRUST BENEATH THE MEGAREGOLITH S. Tompkins¹ and C. M. Pieters², ¹Science Applications International Corporation (SAIC), 4501 Daly Dr., Chantilly, VA 20151, stefanie.tompkins@cpmx.saic.com; ²Dept. of Geol. Sciences, Brown University, Providence, RI 02912

Introduction: The central peaks of 109 impact craters have been analyzed in Clementine UVVIS camera multispectral images in order to assess their mineralogical composition. The craters range in diameter from 40 to 180 km, and are believed to have excavated material in the peaks from 5 - 20+ km depth (1). Representative five-color spectra from spectrally and spatially distinct areas within the peaks were selected and classified on a relative scale, from which mineralogical abundances were estimated. The mineralogical abundances were translated to rock types based on the classification scheme of (2), as illustrated in Figures 1 and 2. Preliminary results characterize a crust that is globally consistent with previous observations, models and predictions, but very compositionally heterogeneous at local and regional scales.

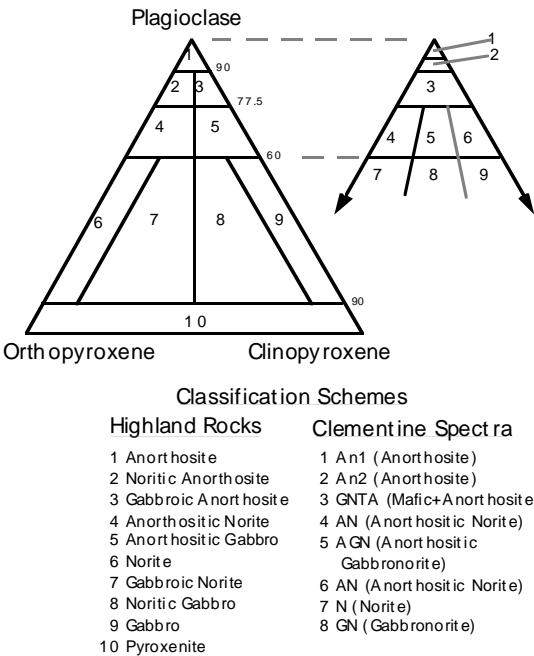


Figure 1 Comparison of highland rock classification scheme (lefthand diagram) of (2) with the classification of central peaks spectra, illustrated here for gabbroic-noritic rocks. Example spectra are presented in Figure 2.

Background: Lunar crustal evolution is generally considered within the framework of the magma ocean model (3). The model explains the abundance of the ferroan anorthosite suite among pristine highland samples (4), as well as many aspects of mare basalt composition. Mg-rich rocks are less easily explained, but are generally believed to have formed as layered intrusions within the anorthositic crust. More recently, the probable existence of layered (differentiated) impact melt sheets has been demonstrated at terrestrial impact

sites (5), and melt sheets have therefore also been suggested as a possible alternate source of Mg-rich rocks on the Moon.

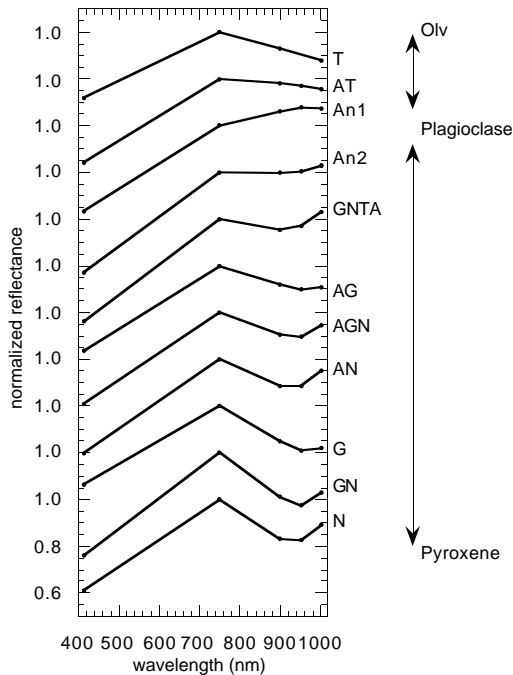


Figure 2 Example spectra for each central peak compositional category (normalized to 750 nm).

Observations and Discussion: The abundance and distribution of central peak lithologies have been examined both laterally (across the lunar surface) and with depth (assuming that larger crater diameters indicate deeper sources of peak material). From these results, several general trends are readily apparent. These trends and their possible interpretations in light of crustal evolution models are summarized below.

- 1) Nearly half of the peaks contain multiple lithologies, indicating that the lunar crust is compositionally diverse at the $10^2 - 10^3$ m scales found within a single crater's central peaks.
- 2) Compositional trends appear to be associated more strongly with lateral variations in the crust than vertical. Those parts of the crust that have obviously been affected by the formation of major impact basins contain significantly more mafic and more compositionally diverse central peaks than do highland areas.
- 3) Those peaks that contain only a single rock type largely consist of anorthosite, and occur most frequently in the highlands. When they do appear in basin-related terrain, it is generally near the rings or rims of impact basins (rather than in basin interiors). This abundant anorthosite is likely to represent the

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upper portion of the plagioclase-rich crust formed during the magma ocean. Basin scale impacts, while stripping away large volumes of crust, have preserved some of this crust in the basin rings and rims.

4) The most abundant rock types in basin-related terrain are more mafic than in the highlands, and generally have low-Ca pyroxene as the dominant mafic mineral. While anorthosite is still plentiful, it frequently occurs with other lithologies that range in composition from noritic anorthosite to anorthositic norite. These are interpreted to be lower crustal rocks made accessible after basin scale impacts have stripped away upper crust. Some of the mafic peaks, regardless of mafic mineral type, may also be Mg-rich suite rocks. Since they often occur in association with basins, it is difficult to determine whether they formed in impact melt sheets or intrusions.

5) SPA Basin is associated with a greater abundance of central peaks with unusually mafic lithologies. The peaks in SPA Basin may be explained by the basin's large size, and the melting and recrystallization of the entire crustal column. These peaks are surprisingly homogenous (all low-Ca pyroxene-rich); if they are part of the SPA Basin melt sheet, differentiation is not readily apparent at the vertical scales sampled by the peaks (see Pieters et al., this volume).

6) The difference in typical composition between highland and basin-related central peaks suggests large-scale differences between upper and lower crust, but higher frequency compositional variability dominates this particular data set (Figure 3). For the 5 - 20 km sampling window of the central peaks, compositional association with a specific depth occurs in only one instance. Among highland craters, the most mafic and most calcic pyroxene-rich rocks occur preferentially among 70 - 85 km diameter craters (about 10 - 15 km depth). The rocks may be the best candidates for Mg-rich suite intrusions in the highland crust.

7) Troctolitic rocks are positively identified in six locations, evenly distributed between highland and basin-related terrain and over the entire depth range sample by the peaks. The existence of troctolites in the highlands argues against their formation through impact melt sheets, although the data set is clearly limited at this time.

Summary: In general, the central peak compositions are consistent with our previous understanding of lunar crustal structure, and support the idea of a compositional gradient from pure anorthosite near the surface to anorthositic norite at depth. Preliminary observations favor the "traditional" concept of layered intrusions into the crust as the source of Mg-rich rocks, and argue against differentiated melt sheets as a possible source. At local scales, the crust is extremely diverse, and more detailed studies are underway to

examine local and regional geology through the windows provided by individual sets of central peaks.

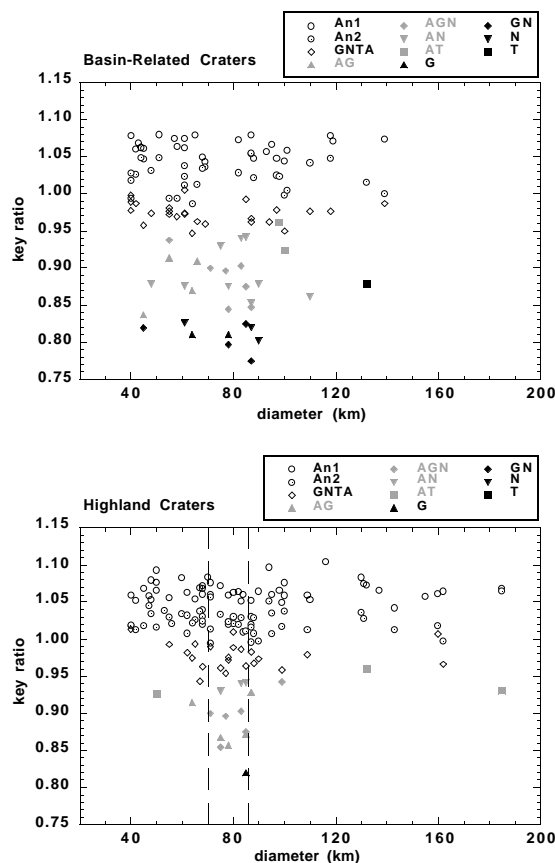


Figure 3 Relationship between central peak composition and depth. Composition is approximated as the "key ratio," which is the ratio of reflectance at 750 nm to reflectance at either 900, 950, or 1000 nm, selected to maximize the ratio for any given spectrum. Depth of excavation is approximated by crater diameter. Dashed lines indicate the cluster of highland craters that may have excavated similar material from a common depth range.

References: 1. M. J. Cintala, R. A. F. Grieve, in *Large Meteorite Impacts and Planetary Evolution* (GSA Special Paper 293, 1994). 2. D. Stöffler et al., in *Proc. Conf. Lunar Highlands Crust* (Pergamon Press, New York, 1980) pp. 51-70. 3. D. Walker et al., 1103-1120 (1975). 4. P. H. Warren, J. T. Wasson, *Proc. Lunar Sci. Conf. 8th*, 2215-2235 (1977). 5. R. A. F. Grieve et al., *J. Geophys. Res.* **96**, 22753-22764 (1991).